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US006301970B1

(12) **United States Patent**

(10) **Patent No.: US 6,301,970 B1**

(45) **Date of Patent: Oct. 16, 2001**

(54) **CUMULATIVE DAMAGE MODEL FOR STRUCTURAL ANALYSIS OF FILED POLYMERIC MATERIALS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/366,763**

(22) Filed: **Aug. 4, 1999**

Related U.S. Application Data

(60) Provisional application No. 60/095,452, filed on Aug. 6, 1998.

(51) **Int. Cl.**[7] **G01N 19/00**

(52) **U.S. Cl.** **73/804**; 73/789

(58) **Field of Search** 73/795, 789, 804, 73/806, 808, 809, 810, 811

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,754,645 * 7/1988 Piche et al. 73/597

5,531,123 * 7/1996 Henkel 73/795

5,736,645 * 4/1998 Chin-Chan et al. 73/799

5,764,068 * 6/1998 Katz et al. 73/778

* cited by examiner

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(57) **ABSTRACT**

A method of predicting fatigue failure in a filled polymeric material is provided. The method involves the calculation of stress at the region of highest stress using an equation which includes as parameters, regression coefficients of the stress vs. modulus obtained from a finite element analysis. Once the regression coefficients are obtained, there is no further need to perform a finite element analysis. The calculated stresses are numerically integrated in a damage equation using a Monte Carlo method, using a cumulative model to estimate when failure will occur. The method has been tested in the case of temperature stress loading of a solid propellant rocket motor.

21 Claims, 5 Drawing Sheets